ARIZONA TRANSPORTATION RESEARCH CENTER

RESEARCH NOTES:

Project SPR-601

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A Cost Evaluation of Cross-Border Truck Emissions Testing Using Heavy Duty Remote Sensing Equipment

This research study was undertaken to identify current and emerging technology for testing large truck emission using heavy duty remote sensing (HDRS) equipment. Findings from the literature review were used to design an HDRS emissions testing station for heavy duty trucks at one of Arizona's land port of entry (LPOE). A cost estimate for purchasing and installing the emission test station was also prepared.

Literature Review

An examination of the literature identified numerous vendors and equipment for the measurement of vehicle emissions. Emissions measurement systems and programs for light-duty vehicles (gross vehicle weight under 8500 lbs) are well defined in the literature, a part of the State of Arizona's motor vehicle Inspection and Maintenance (I&M) program as well as other state's within the U.S. as well as other countries. Most of these systems rely on an I&M program that is tied to a vehicle registration program. In the U.S., most states use the SAE J1667 snap-acceleration test to measure gaseous pollutants and opacity. A cup-like device is used to capture emissions from the vehicle's exhaust prior to screening by equipment.

Unlike I&M programs, remote sensing is the measurement or acquisition of information about an object by a recording device that is not in contact with the object. Remote sensing devices (RSDs) are designed to estimate emissions from light and heavy duty vehicles. As an example, the HDRS technology used for the Nogales, AZ border study utilized both ultraviolet and infrared light beams to instantaneously measure hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NO_X), and particulate matter of size 2.5 microns or less ($PM_{2.5}$) from heavy duty truck exhaust. Although HDRS emissions measurement technology has been around for about 15 years, and its efficiency continues to improve, it has not been demonstrated on a large scale,

HDRSD is still an emerging technology. It has performed well as an emissions screening tool, but has not been used as a

primary emissions program. Identifying deployment and set-up strategies for varying truck traffic conditions continue to be a challenge. One such challenge is the varying height and location of the exhaust muffler on different models of heavy duty diesel trucks.

Numerous vendors of emissions measuring equipment are available in the market place. However, when the criteria is narrowed to vendors providing remote sensing equipment, especially instruments designed to measure emissions from heavy duty diesel engines, the field is narrowed to a handful of suppliers.

Data Collection

Using the findings from the literature review an HDRS data collection system (design) was developed for ADOT that can be used along one or more LPOEs at the Arizona-Mexico border. The data collection plan includes sufficient details to identify the ideal components of an HDRS system such as instrumentation, reliability, emissions capture-measurement-exhaust system(s), data acquisition system, other information technology components, housing or enclosed structure, etc. The details of the data collection plan are also sufficient to support the operations of a successful program.

Prior to designing the HDRS data collection system, members of the research team visited the Nogales, AZ LPOE. The facility borders Nogales, Sonora, Mexico, and supports pedestrian, passenger vehicle, and commercial vehicle crossings. The Nogales-Mariposa LPOE also has the largest volume of traffic for all Arizona-Mexico border crossings.

A proposed site location for the HDRS equipment station was identified on the north perimeter road near the exit for the facility. This location was chosen after reviewing the directional flow of truck traffic into and through the LPOE, and incorporating proposed expansion plans. The exit road also has a slight uphill grade that requires the driver to accelerate the vehicle – an ideal situation for measuring vehicle emissions.

Potential Alternatives

Three alternatives for HDRS emissions testing are proposed: a) basic system, b) intermediate system, and c) fully-integrated system. Each has the capability of measuring four key pollutants: HC, CO, NO_X, and PM.

The basic system would have two remote sensing transmitter units (one operating and one spare) mounted on a tower, a receiver and computer (inside a basic shelter) mounted on a tower on the opposite side of the exit road for the LPOE. This system would require power (110 volts, separate circuits) on each side of the roadway, and space for mounting towers high enough to send a beam through the truck exhaust.

The intermediate system builds on the basic system. It includes all equipment identified in the basic system and two additional instruments: a continuous particulate monitor (PM_{10} or a modification to measure $PM_{2.5}$), and an aethalometer to provide continuous measurement of diesel particulate matter (black carbon).

The third alternative for a data collection plan is the fully-integrated HDRS emissions measurement system. Similarly, it builds on the intermediate design. The equipment list for this system includes two remote sensing transmitter units (one operating and one spare) mounted on an exterior column of a *pole barn* (roadway canopy), or mounted

from the inside roof beams of the pole barn that would extend over a section of the facility's exit road. A third remote sensing unit would be placed inside a mobile equipment shelter and deployed at a specific distance from the units in the pole barn to capture exhaust under acceleration. Other equipment includes a continuous particulate monitor (PM_{10} or $PM_{2.5}$) , a rack mounted and portable aethalometers that provides continuous measurement of black carbon, a continuous NO_X monitor, a continuous sulfur dioxide (SO_2) monitor, and the option for measuring speciated hydrocarbons as needed

The intermediate system requires 110 volts of power on each side of the roadway. Space is required to mount the transmitter and receiver high enough to send a light beam through the truck exhaust. Equipment can be mounted either from vertical beams on the side of the pole barn, or from the inside ceiling of the structure. A sample collection hood could also be mounted from the ceiling of the pole barn to capture truck exhaust for more extensive component measurement (e.g. air toxics or hazardous air pollutants (HAPs)). The building could easily accommodate additional equipment and personnel, if desired, for special studies.

Cost Estimates

A conceptual cost estimate was developed for each data collection design and includes the installed cost for all equipment, and operations and maintenance (O&M) costs for five years. Price quotes were obtained from equipment vendors, a previous contractor for an Arizona Department of Environmental Quality (ADEQ) emissions study was consulted, and staff of ADEQ's emissions monitoring unit were also consulted for input in developing the cost estimates.

The basic system proposes the use of one (1) full-time equivalent (FTE) personnel, the intermediate system requires 1.2 FTE, and the fully-integrated system requires 1.5 FTE. Initial estimates were developed using contract labor. Alternate estimates were also developed to show the cost differential in using employee labor, and is largely dependent upon ADOT's ability to attract and retain a highly skilled employee(s) to operate and maintain this level of sophisticated equipment. Present worth cost for each data collection system is provided in Tables 1 and 2.

Table 1: Present Worth Cost (Contract Labor)

HDRS Emissions Measurement System	Present Worth (2008)
Basic System	
Equipment	$564,808.00
O&M Costs	756,020.00
Total	$1,320,828.00
Intermediate System	
Equipment	$613,008.00
O&M Costs	1,086,638.00
Total	$1,699,646.00
Fully-Integrated System	
Equipment	$1,044,524.00
O&M Costs	1,132,943.00
Total	$2,177,467.00

Table 2: Present Worth Cost (Employee Labor)

HDRS Emissions Measurement System	Present Worth (2008)
Basic System	
Equipment	$564,308.00
O&M Costs	576,041.00
Total	$1,140,349.00
Intermediate System	
Equipment	$611,308.00
O&M Costs	687,584.00
Total	$1,298,892.00
Fully-Integrated System	
Equipment	$1,056,524.00
O&M Costs	866,723.00
Total	$1,923,247.00

As expected, the use of employee labor would be cheaper (14 to 31%) for full-time operation of the three systems. Future costs or *the cost of waiting* were also projected for each data collection design.

This study provided a cost estimate for a HDRS emissions measurement system at one of Arizona's LPOEs. Although significant advances have been made over the last 10 years, HDRSD is still an emerging technology. HDRSD technology has performed well as an emissions screening tool, but has not been used as a primary emissions program. Identifying deployment and set-up strategies for varying truck traffic continues to be a challenge. One such challenge is the varying height and location of the exhaust muffler on many heavy duty diesel trucks.

Recommendations

The following recommends are provided to ADOT as a follow up to this study:

- Form a partnership with ADEQ. ADEQ is responsible for the state's motor vehicle I&M program. Adding a vehicle emissions monitoring station at the border, other than as a pilot program for clean screening, would need to adhere to the existing regulations, policies and procedures that are in-place. A partnership between the two agencies will provide for coordinated work efforts, possibly shared costs for equipment and staffing, and better use of resources within each agency.

- Consider HDRS screening program. Due to current limitations with the emerging HDRS technology, ADOT may consider pursuing an emissions screening program for heavy duty diesel trucks at one of its LPOEs. The proposed screening program may operate during the peak season (October to May) when truck traffic is at its maximum. In this way, enough trucks are screened, but not all trucks are screened. Improved emissions measurement is certainly expected to be one objective of an HDRS program.

- The results of the research show that installing an HDRS emissions measurement system at the border is not an inexpensive project. Stated earlier, grant funding may be available to install and operate a HDDV clean screen program. The Arizona Legislature as well as EPA may also be petitioned as a funding source for a project of this type.

The full report: *A Cost Evaluation of Cross-Border Truck Emissions Testing Using Heavy Duty Remote Sensing Equipment* by Vi Brown, Prophecy Consulting Group, LLC, 2005 S. Henkel Circle, Mesa, AZ 85202 (Arizona Department of Transportation, report number FHWA-AZ-08-601, published June 2008) is available on the Internet. Educational and governmental agencies may order print copies from the Arizona Transportation Research Center, 206 S. 17th Ave., MD075R, Phoenix, AZ 85007; FAX 602-712-3400. Businesses may order copies through ADOT's Engineering Records Section.